Gestural, Emergent and Expressive: Three Research Themes for Haptic Interaction

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Abstract. Drawing on three case studies of work in the fields of participatory design, interaction design and electronic arts, we reflect on the implications of these studies for haptic interface research. We propose three themes: *gestural*; *emergent*; and *expressive*; as signposts for a program of research into haptic interaction that could point the way towards novel approaches to haptic interaction and move us from optic to haptic ways of seeing.

Keywords: Haptic interaction, gesture, emergent interaction, expressive interaction, passive haptics, ways of seeing.

1 Introduction

Research in the field of haptic interaction has been dominated by a representational approach, which emphasises haptic fidelity and focuses on the simulation of real-world, physical objects and materials. Although this approach has obvious practical utility, it excludes consideration of potentially fruitful alternative approaches to haptic interaction, which have so far received less attention. Working from our combined backgrounds in participatory design, interaction design and electronic arts, we see potential in an alternative and less literal approach to haptic interface design - one which emphasises haptic interactions' gestural, emergent and expressive qualities.

The aim of the paper is therefore to expand the bounds of haptic interaction design. More specifically we aim to identify some broad research themes for exploring non-representational haptic interfaces, interaction designs and research. These insights stem from the authors' previous work and are generated through the use of Reflective Practice methods (e.g. [1]) in addition to theoretical research.

The paper is broadly structured in two parts. In the first part, outlines our approach to the subject of haptic interaction design which is grounded in a broad reading of literature relating to perception and sensory experience – drawing from HCI, philosophy and media studies. The second part of the paper consists of three case studies on interactive systems created by each of the authors. These highlight the themes of gestural, emergent and expressive interaction as fertile areas for exploration in relation to haptic interfaces. Each of the interactive systems, through practitioner reflection and case study analysis, reveals a theme. These themes combine with the theoretical insights gained through the literature survey to point towards a less conventional,

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non-representational haptic design and research agenda. We believe that such a research agenda has the potential to expand the domain of haptic design and research, to lead to new knowledge and approaches for addressing problems within Interaction Design - ranging from the exploration of complex data sets through to affective interaction, embodiment, and applications in health.

2 Background

Haptic perception involves the somatosensory system that a complex array of sensory receptors associated with our embodied tactile experience of objects and the world – essentially the human perceptual abilities of extroception and proprioception. While haptic rendering in engineering and the sciences typically distinguishes between active haptics and passive haptics. The difference is one of response – where force feedback is provided to the user, the system is active and where there is no force feedback provided in real-time, the system is considered passive. The significance of the passive haptic system is its potential to leverage everyday passive objects and their affordances. This is a driving force behind the Tangible Computing field of research [2]. Such definitions provide a clear outline of the haptic sensory modality and the ways it can be studied in a quantitative manner, and employed in the development of functional haptic interfaces. However, through the literature in the field of haptic interface design and research haptic interfaces are commonly combined with 3D simulations of space and objects. To help us understand this relationship between haptic and visual perception, and the preference for combining haptic interfaces with 3D representations of the real world and objects we begin by looking at the etymology of the term haptic. Haptic originates from the greek *haptesthai,* to fasten onto, to touch [3]. This provides a point of departure for approaching haptic, that our touch fastens us in the world, as opposed to sight that situates us within a continuous space as distinct subjects. Touch, and our hands, draw us into the world.

Outside of HCI and human factors, philosophers and theorists have addressed the subject of haptic perception from a cultural, phenomological and social perspective. From McLuhan's [4], [5] understanding of electronic media as tactile to Deluze and Guattari's notions of smooth and striated space [6], to more recent work looking at the haptic visuality and tactility of film [7], [8] to the design of haptic interface technologies and computer space [9] and haptic interfaces from a cultural, ethic and social perspective [10]. This body of work provides valuable cues to how to develop a haptic research agenda, without falling to what Hansen describes as an ocular centric paradigm [11].

Of specific interest in this paper is the distinction made between haptic and optic ways of seeing, and understanding space. This distinction, which has it origins in the work of visual arts theorist Reigl involves understanding the way image and space are represented and perceived in visual media forms, from painting to film to computer games, by different cultures and societies [9]. The distinctions between haptic and optic ways of seeing are grounded in the relationships between culture, subjectivity and perception, and the representation of objects in space. Put simply, optic space

organises objects within in a unified spatial continuum (e.g. perspective) and establishes a viewing distance between the viewer and objects, as such the viewer can situate themselves as viewing subjects. By contrast haptic space focuses on the surface, concerned with tactility and texture rather than illusionary depth [7]. Haptic visuality considers the experience of seeing as an immersion in colour, light and movement – to feel the work with the eyes, to be drawn too close. This is well summed up by Cézenne when he describes immersion in the visual filed and how this translates into artistic techniques [12].

It is Deleuze, however who discusses the way haptic space is a space in which neither the hand nor the eye are subordinate [13]. While haptic interfaces remain coupled to 3D simulations of optic space and objects, there remains a subordination of the hand to the eye. It is this sense relationship that we see as central to developing an approach to both research into haptic interaction and the design of haptic interfaces.

This desire to draw us into the virtual world, through the combination of 3D computer graphics and haptic interfaces echoes the 1990s dream of immersive virtual reality – a vision which has not come to pass as imagined by its originators. Instead the digital world has become integrated into the 'real' world in a more seamful, mixed manner, and has lead to theories of embodiment [14], emergence [15], aesthetics [16], [17] and somaesthetics in interaction design [18].

3 Cases

Following we present three case studies, which highlight the themes of gestural, emergent and expressive interaction as fertile areas for exploration in relation to haptic interfaces.

The gestural case study describes research into the use of gestural interaction in the context of a skilled workplace - dentistry. Through extended field studies and a participatory design process, gestures were investigated as a possible means of interacting with computer systems. This work highlighted important qualities of gestural interaction for interface design, which are also highly relevant for work in the area of haptic interfaces. Especially relevant is the finding that gestural interactions can usefully be conceived as skilled movements encompassing both movements we would conventionally consider gestures (communicative hand movements) as well as the skilled haptic tool-manipulation movements of dentists as they work.

The emergent case study concerns the interactive artwork *+-NOW,* which has a tangible user interface. During participant interaction with the work, emergent behaviours were found to occur. The discussion reflects on the role of materials, their affordances and the design of the haptic interface in effecting these surprisingly new, participant behaviours. The discussion draws on theories of emergence, game design and perception. it also includes excerpts of participant interaction with the artwork to exemplify the emergence.

Finally, the expressive case study draws on work from the context of electronic arts to reflect on the expressive possibilities of haptic interaction. This case draws on the interactive artwork *Pulse Guantlets,* which explores the evocative, poetic and playful aspects of interaction. The discussion centers on how attention to aesthetic qualities of

interaction can create more meaningful, memorable and impactful contexts for experience around issues related to inter-personal relations.

3.1 Gestural

The first of our case studies was taken from a design research project, which investigated the design of a gestural interface for use in the context of the dental surgery. What emerged from this study was a broad and inclusive view of gesture as skilled embodied movements (Fig. 1). Any movement of the body can be considered a gesture. Gestures can be produced for a variety of purposes, including for the purpose of expressing meaning to another or oneself, to explore meaning or gain information from the world, and to manipulate objects effect material changes in the world. Gestures should be understood as socially and environmentally situated [19].

Fig. 1. An inclusive view of gestures as skilled movements

This framework presents a quite radical understanding of gesture compared to the view that has previously been taken in gesture interface research, which typically considers only the leftmost end of the continuum above – gestures made to express meaning to another or oneself [20]. Although this conventional focus of gesture interface research has the attraction that it lines up with an everyday understanding of gesture as *communicative* movements, it is limiting for framing a theoretical understanding of gestural activity for Human Computer Interaction, because it cuts off consideration of other kinds of gestural movements that might be usefully employed in interaction design and diminishes the possibility of creating connections between gestural interaction and other fields, such as haptic interaction, which are also fundamentally concerned with human capacities for skilled (gestural) movement.

Furthermore, considering gestures as *only* communicative movements is challenged by findings from empirical studies of existing contexts of use. As part of the case study, a detailed analysis of video recordings of dental practitioners at work was carried out in order to understand the kinds of gestural interactions that occur there. As one would expect, this study clearly showed that gestures are employed in supporting communication between the dentist and patient, especially where the dentist had to explain concepts from dentistry. However, the study also revealed the role that gestures play coordinating the activities of dentists, patients and dental assistants as they go about their work. These coordinative gestures presented a continuum of gestural interactions from more directly communicative in purpose through to gestures that were intimately tied to the use and manipulation of physical instruments and materials in the dental examination [19].

These findings accord with insights from other studies of human gesture, which point to deep links between gestures and: sensorimotor-experience, cognition and learning [21], [22]; tool-use and manipulation [23], [24]; and the coordination of

situated human interaction [25], [26]. It is simply not the case that there is a clearly separable boundary between different purposes of skilled movement. Rather, skilled movements *are* skilled by virtue of the fact that practitioners are able to enfold multiple modes of embodied activity into situated fields of interaction [25].

In terms of design, this view suggested the concept of a 'gestural dental instrument' (Fig. 2), which was an augmented dental instrument capable of detecting movements acting on it which the dentist could use during a dental examination to interact with a computer interface. From the perspective of gesture interface design, this design concept points to the possibility of designing input devices that allow a range of kinds of gestural interaction, from more communicatively focused on physical manipulation, or meaning making gestures. It also suggests questions for haptic interface research around how haptic input and feedback could be coupled with a broad range of gestural interactions, and what possibilities this would raise for the design of haptic interfaces.

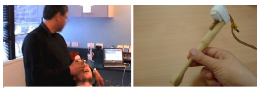

Fig. 2. Prototype of a 'gestural instrument' for use in a dental examination

3.2 Emergent

The interactive art system *+-NOW* (plus minus now) [27] uses sand as a continuous, tangible interface. The audience can interact with this passively haptic medium to create two types of imagery – the colourful augmented reality image that is projected directly onto the fine, white beach sand; and the monochromatic image that is rear projected onto a wall screen. Gestures in the sand effect 'layers' of imagery in response, like visual echoes that mimic the shape, direction and speed of a mark in the sand with repeated renderings (see below). These 'visual echoes' of gestures add up in opacity to create areas of increased brightness on the wall image, enabling the interpretation of new shapes. At the same time the image persists and one can interact with a history of one's gestures. In this way the work facilitates "…layering and moving across time" [27].

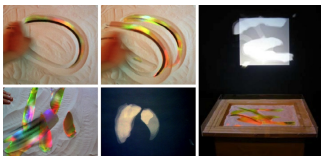

Fig. 3. The interactive art system *+-Now,* 2008

During its three month installation at Beta_Space in the Sydney Powerhouse Museum, a qualitative evaluation of the public's experience and interaction with the work was conducted [28], [29]. Findings from this study have reframed this author's (and artist's) understanding of haptic interaction, particularly as it relates to those non-traditional human computer interactions that are not focused on supporting clearly defined goals and behaviours.

Audience behaviours while interacting with the work were a particular focus of the study. Following the Constructivist viewpoint of perception it is possible to look at these people's behaviours in terms of the environment that they occurred in, and in particular, at the materials that they interacted with [30], [31]. Thus the affordances of

the sand are a key influencer in the behaviours observed. Not surprisingly then it was found that a number of participants 'made marks' in the sand or created drawings. Given the temporal quality of the work – the fact that the image persists after the gesture and can layer – it also meant that it was possible for people to animate. (See the example of one person's interactive animation of a heartbeat, shown above). Given that sand affords drawing and mark making, the interactive animation behavior is not surprising. Other less predictable and relatively novel behaviors were also observed. These *emergent* behaviors include 'stir look feel' and 'follow lights'. The first involved stirring the sand then looking at the imagery to wait and see what might appear. The second behavior involved making clearings in the sand and then touching them as coloured light would appear in them (for more detail see [32]). Both of these game-like behaviors rely integrally on the affordances of the interface – whether to stir up this continuous, analogue material or to make small holes in it, mounding it around the sides. These participant behavior that emerged are largely due to the nature of the sand interface – and how people perceive it.

Emergent behaviors are not a new concept in gameplay. Emergent games are one of two kinds, as described by theorist Juul [15]. This is the open-ended game that facilitates new and surprising outcomes and is different with every re-play. The other is the progressive game where for example a player meets a sequence of challenges. Bluffing in the game of poker is an example of an emergent behaviour. It is not explicitly defined in the rules of Poker. Other research into emergence literature, perception and haptics have combined with the evaluations of participant interaction with *+-NOW* to reframe this author's view of haptics. The insight gleaned is to consider the affordances and other material attributes of the haptic, tangible interface as analogous to rules in a game, given that both influence and determine the participant's behavior. This shift in design perspective locates haptics at the forefront of the design process for creating emergent interactions. Such design work can be further informed by a framework of emergence in interaction [28]. This framework is based on theoretical research. It provides further scope in the creation and evaluation of haptic interactions that are creative, surprisingly new, unpredictable and emergent – in short, non-traditional HCI.

3.3 Expressive

To feel another person's pulse is an intimate and physical interaction. The work *Pulse Gauntlets* – created by Gavin Sade, Priscilla Bracks and Dean Brough – employs near field communications[1] to extend the tangible reach of the human heart beat, so another person can feel our heart beat at a distance. The work is an initial experiment in near field haptic interaction, and was initial created for presentation at the *Haptic Interface* Exhibition[2] in Hong Kong in late 2012. The focus of the work was to ex plore the quality of interactions resulting from feeling another persons pulse.

[1] In this work we use XBee Series 1 Radio Frequency transmitter receivers from Digi.
[2] `http://hapticinterface.hkbu.edu.hk/`

The work takes the form of two feathered white gauntlets, to be worn on the forearm. Each of the gauntlets contain a pulse sensor, XBee radio frequency transmitter receiver, a pink LED and a small vibration motor. The pulse of the wearer is recorded and transmitted to the other gauntlet where it is transformed into haptic feedback, in the form of a short pulse of the vibration motor, which makes direct contact with the skin. The length and intensity of the vibration were aesthetic variables manipulated to achieve a desired feeling of a "heartbeat", without the vibration being either an annoying buzz or unperceivable.

Fig. 4. Pulse Gauntlet - showing final visual form, with feathers, white leather and pink LED

The pair of *Pulse Gauntlets* are the first stage of a more ambitious project that will involve a larger number of similar gauntlets, all broadcasting pulse of the respective wearers. The aim of making this larger haptic interactive system is to explore interaction within larger groups, and development of new use cases through observing emergent behaviors of wearers.

The *Pulse Gauntlets* are the result of a practice-led approach – which means the practice of making in the studio came before the formulation any specific research question. As opposed to a typical engineering or HCI approach, practice-led research is emergent in nature, with both questions and new knowledge emerging through practice. In this respect the *Pulse Gauntlets* need to be seen as the result of creative practice, as opposed to being a goal directed research. Aesthetic decisions, choice of materials and even conceptual connections all arose from interplay of making and thinking about making which occurs within the studio, and reflection upon the outcomes. In this setting the aesthetic qualities and resolution of the final objects were an important focus of the practice, and as such the gauntlets are more than a technically function prototype produced as a research instrument. Instead the gauntlets can be considered a finished creative outcome that embodies some of our thinking about haptic interaction, which can only be experienced through actually wearing one of the gauntlets.

The physical materials from which the gauntlets are fabricated play an important role in the passive haptic experience of the work. This careful concern for aesthetics and the textural quality of material is an aspect that is sometimes missing in research focused on active haptic systems. The textural and physical qualities of the leather and ostrich feather play an important part in the final haptic experience of the pulse gauntlets – and form part of a carefully crafted visual aesthetic, which is a pastiche of minimal science fiction and flamboyant glam rock. The feel - touch - of the leather and the encompassing gauntlet draw attention to the forearm, the physical size and extent of the feathers alters the way the arm is normally held in relationship to the body, and similarly alters and draws attention to the arms' movements through space.

From the experience of the gauntlets in the studio to the reception of the work at *Haptic InterFace* Exhibition in Hong Kong in late 2012, several key observations have suggested future directions for research into haptic interaction. Most notable is the way the direct haptic exchange of heart beat between two people was responded to by wearers, and then the way this haptic interaction changes the wearers experience of

each other over longer periods of time. In the studio the artists wore the gauntlets in varying stages of completion and for longer periods of time than at *Haptic InterFace*. In this setting changes in pulse rate were observed by each person, and often in respect to the nature of interpersonal interactions or tone of conversations. For example, on several occasions wearers noted an increasing pulse rate during a more stressful conversation, and the observation of the increased heart rate altered the interactions in ways that would not have otherwise occurred. Over longer periods of use the wearers would walk around the studio and in and out of the XBee modules' communications range. The wireless range of the XBee modules was beyond direct line of sight, but did not cover the whole studio. As a result the wearers became aware of proximity, by way of haptic feedback of the other persons heartbeat, often well before seeing each other. Thus developing a tactile bond beyond physical touch or sight.

It is the extension of the intimate feeling of another persons heartbeat which has been the focus of most interesting comments from people wearing the work. During the presentation of the work at *Haptic InterFace* many people wearing the gauntlets were uncomfortable about feeling another persons pulse in such an intimate way - especially when the over person was a stranger. This was often the case many interactions involved the artist (Gavin) wearing one of the gauntlets and a visitor to the exhibition wearing the other. If the heartbeat was not felt in a haptic manner this response was be reduced or did not occur – i.e. before the gauntlet was put on the heartbeat could be seen visibly by way of a LED.

In discussion about the design at *Haptic InterFace* the most surprising comment was that people about to put on a gauntlet needed to be informed people of the function of the gauntlets, and that there needed to be permission gained before they put the gauntlets on. While there were didactic materials, many people put the gauntlet on prior to knowing its actual function. The apparent need to inform and gain permission for what was initially thought a rather unproblematic concept was surprising. This raises several possible explanations for what is it about the tangible feeling of stranger's pulse that is concerning, or off-putting. Perhaps the form of the gauntlet was a factor – as it wraps around and encloses the majority of the forearm. Or maybe the direct feeling of another heartbeat while seeing the person at a distance introduces an experiential tension, or disconnection – as it is an experience that one cannot have without technological mediation. Also, as an experience it is grounded in one of a few social interactions typically medical or intimate in nature.

4 Discussion and Conclusions

This paper grew out of a series of discussions between the authors as researchers interested in the field of haptic interaction wondering what our previous research might have to offer the field of haptics research. As such, it has not been our aim to present a comprehensive research program for haptic interaction – but rather to express what we see as our own possibilities for contributing to the field. We have presented this as three themes – drawn from our previous research – of *gestural*, *emergent* and *expressive*. In order to focus what we see as the core ideas of these three thematic areas we have developed a series of questions related to haptic interactions in each theme.

Table 1. Guiding questions for themes

Theme	Guiding quesionts
Gestural	• How do the interactions connect with a continuum of skilled gestural movements? • Do the interactions support the coordination of work or maintenance of shared understanding between interactants? • Do the interactions allow people to explore and make sense of the world?
Emergent	• How do haptic interactions evolve and emerge over time? • How are interactions layered within the interface? • How are interactions supported by the affordances of the interface?
Expressive	• What are the social and cultural significances of the interface? • How does the interface unsettle or reframe ordinary ways of experiencing? • How does the interface make use of aesthetic and expressive dimensions?

The case studies also show the importance of **passive haptic** systems and suggest that this may be a valuable path for further investigation. In that work has to date not paid as much attention to the design of the tangible materials and the way this influences experience interaction and communication, and is in itself culturally loaded. While there has been some work in this area of tangible interaction there is more work to be done in developing an understanding (useful interaction design knowledge) of the role haptics play in gestural, emergent and expressive applications.

Similarly there is work to be done to develop a useful way of describing the parameters or variable that influence haptic interface design and how these can be manipulated to achieve specific design outcomes. Of interest would be developing a framework which shows **how haptic qualities align with established qualities of interaction**, for example those presented by Löwgren and Stolterman [33]. Such knowledge would allow interaction designers develop tangible interaction design concepts which bridge the digital material divide.

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